# REPORT

# ARS

# BARLEY YELLOW DWARF VIRUS

# WORKSHOP

## ST. LOUIS, MISSOURI

## MAY 10-11, 1995

# AGENDA

**ARS Barley Yellow Dwarf Virus Workshop**
**St. Louis, Missouri**

**May 10-11, 1995**

| | |
|---|---|
| Welcome and Workshop Objectives | Chuck Murphy<br>Roy Gingery |
| Introductions and Program Overviews | Participants |
| Establish Host-Virus-Vector Research Needs | Participants<br>(Normal Group Technique) |
| Prioritize Research Needs | Participants<br>(Normal Group Technique) |
| Inventory Current Activities | Participants |
| Summary, Thoughts/Concerns | All |

# ARS

# BARLEY YELLOW DWARF VIRUS

# WORKSHOP

# PARTICIPANT INFORMATION

Dr. Joseph M. Anderson
USDA, ARS, Mid-West Area
Agronomy Department
Purdue University
1150 Lilly Bldg., Room 2-302
W. Lafayette, IN 47907

Dr. Anderson is a Research Molecular Biologist with Agricultural Research Service. His research responsibility is to initiate a program to reduce losses of small grain cereal crops due to viral diseases (primarily Barley Yellow Dwarf Virus) during crop production. This program concerns the genetic, molecular, and biochemical basis of BYDV host interactions in small grain cereals with a long term goal of elucidating and implementing mechanisms for stable resistance to BYDV and subsequently to other important viruses in small grain cereal crops. The specific objectives of his research are (1) Construct transgenic wheat plants containing viral genes (primarily replicase genes) from BYDV subgroup I and II strains and determine if these viral genes will inhibit virus establishment or replication, (2) Identify, isolate and characterize genes for BYDV resistance in wheat and barley, determine the molecular genetic and biochemical basis for resistance and develop models for virus resistance mechanisms, (3) Analyze carbohydrate metabolism biochemically and molecularly in healthy and infected plants to define more clearly the effect BYDV infection has on carbohydrate flow and plant growth.

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Ms. Catherine Chay
USDA, ARS
Tower Road
Ithaca, NY 14853

Ms. Chay is currently conducting research on the role of the BYDV readthrough protein in circulative transmission of virus and genetic diversity among field isolates. Her interests include approaches to utilizing viral-indicated resistance for BYDV in wheat.

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Dr. Leslie L. Domier
USDA, ARS, MWA, CPRU
N-325 Turner Hall
University of Illinois
1102 South Goodwin
Urbana, IL 61801

Dr. Domier is a Research Plant Pathologist with Agricultural Research Service. The long-term goals of his research on the hosts of BYDV are to understand the genetic and biochemical mechanisms by which tolerant oat plants are able to survive and thrive in the presence of BYDV infection. Work is in progress to identify cDNA clones of mRNAs preferentially expressed in tolerant oat genotypes. Infected and non-infected pairs of near-isogeneic oat lines differing in their level of tolerance to BYDV have been used as sources of RNA for substractive cloning and differential expression studies. The segregation of cDNA clones of differentially expressed mRNAs relative to BYDV tolerance is being evaluated using populations of oat lines segregating genes for tolerance to

BYDV. Mapping of differentially expressed cDNA clones will more precisely delineate the tolerance loci and map the differentially expressed cDNA clones relative to the tolerance genes.

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Dr. Jesse Dubin
CIMMYT
Lisboa 27 Apdo, Postal 6-641
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MEXICO D.F.

Dr. Dubin is a Plant Pathologist with CIMMYT. His present BYDV effort includes (1) screening germplasm for resistance/tolerance to BYDV; (2) studying the genetics of BYDV resistance/tolerance; (3) identification of BYDV resistance/tolerance in small grains and wide crosses (e.g., Thinopyrum intermedium); (4) worldwide strain survey of BYDV; and (5) BYDV Newsletter.

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Dr. Michael C. Edwards
USDA-ARS Northern Crop Science Lab
1307 18th Street North
Fargo, ND 58105-5677

Dr. Michael Edwards is a Research Plant Pathologist with Agricultural Research Service. BYDV is not the major focus of his research program although he occasionally participates in BYDV research. His lab has cooperated in a recent study of the effects of BYDV infection on barley malt quality and assisted extension personnel and plant breeders with disease diagnosis and resistance breeding programs. The main thrust of his research program involves the study of virus-barley interactions, with emphasis on the study of barley stripe mosaic and oat blue dwarf viruses because both occur annually in small grains, and both provide excellent opportunities for the improvement of the lab's improvement of their fundamental knowledge of the molecular virus-host interactions that result in resistance, or susceptibility and disease development. Although OBDV and BYDV are quite distinct, both are phloem-limited. Thus, the study of OBDV pathogenesis may contribute to a better understanding of BYDV pathogenesis. They are currently studying the relationships between viral genome structure, gene expression, and pathogenicity using both virus systems. They are also mapping the BSMV resistance gene(s) in barley with the long term goal of characterizing the resistance gene(s) and determining the mechanism of resistance. Dr. Edwards is involved in a cooperative project with the National Small Grains Germplasm Research Facility to eliminate BSMV from the barley entries in the National Small Grains Germplasm Collection (the 'working collection'). Finally, Dr. Edwards coordinates the Mississippi Valley Uniform Regional Barley Nursery. Data from this nursery are utilized by both public and private breeders in the U.S. and Canada to guide breeding programs; thus this nursery is essential to the development of new malting barley varieties adapted to the upper Midwest.

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Dr. Roy C. French
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East Campus, Room 426, PLSCI Bldg.
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Lincoln, NE 68583

Dr. Roy French is a Research Plant Pathologist with Agricultural Research Service. His responsibilities and interests include RNA virus gene expression, replication, and regulation and the interaction of these processes with host plants, particularly wheat and other cereals. He is also interested in the development of molecular-based virus diagnostic tools for plant virus detection and population genetic/epidemiological studies. The polymerase chain reaction (PCR) has been adapted to detect and identify a wide spectrum of wheat viruses including the five major BYDV strains, i.e., MAV, PAV, RMV, RPV, and SGV. A present goal is to develop rapid, nonradioactive, solution hybridization methods to reliably differentiate BYDV strains determine their prevalence in the central U.S.

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Dr. Roy E. Gingery
USDA, ARS, NPS
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Beltsville, MD 20705
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FAX: (301) 504-5467

Dr. Roy Gingery leads the ARS Plant Health research program. His responsibilities include strategic planning and guidance of ARS plant pathology research and coordination of this research with other Federal, state, private, and international institutions. He serves as ARS contact and resource person for questions concerning plant diseases.

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Dr. Stewart M. Gray
USDA, ARS, NAA
Cornell University
Tower Road
Ithaca, NY 14853

Dr. Stewart Gray is a Research Plant Pathologist with Agricultural Research Service.

Research efforts on BYDV at Ithaca, NY, are directed at two major projects: (1) developing an understanding of how luteoviruses are transmitted by their aphid vectors, and (2) investigating the epidemiology of BYDV and potential control strategies for BYDV in small grains. Research efforts under the umbrella of these two projects include numerous collaborative efforts with scientists at Cornell and other universities. Collaborators' names and location are listed after each objective.

The objectives of their studies on aphid transmission include the identification of (1) aphid factors responsible for the binding and uptake of virus (Gildow and Cox-Foster, Penn. State Univ.), (2) BYDV proteins and protein domains required for aphid transmission (Gildow, PSU; Miller, Iowa State Univ.; Young, Montana State Univ.), and (3) BYDV proteins and protein domains responsible for vector-specific transmission of BYDV isolates (Young, MSU).

Objectives of their field studies include: (1) an understanding of the

seasonal phenology of the major BYDV aphid vectors in the corn, wheat and oat crops; (2) identifying the BYDV isolates prevalent in each crop; (3) understanding the movement of vectors and virus among the cereal crops (Power, Cornell); (4) understanding the epidemiological impacts of host resistance to BYDV, insecticidal control of vectors and planting date adjustments (Bergstrom, Cox and Sorrells, Cornell); and (5) characterization of resistance and mapping of resistance genes in oat (Sorrells, Cornell).

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Mr. Scott Heisel
American Malting Barley Association, Inc.
735 N. Water Street, Suite 908
Milwaukee, WI 53202-4105

Mr. Scott Heisel is the Assistant Technical Director of the American Malting Barley Association. Since Mike Davis is unable to attend this Workshop, Mr. Heisel represents the interests of the American Malting Barley Association and the National Barley Improvement Committee.

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Dr. Wojciech Kaniewski
Monsanto, New Agricultural Products
700 Chesterfield Village Parkway
St. Louis, MO 63198

Dr. Kaniewski is a scientist with Monsanto. He has been involved in basic and applied research in plant virology for the past 23 years. Recently, his main interest has been to generate and evaluate virus-resistant transgenic plants. The Monsanto Virus Group has successfully engineered transgenic plants, and has demonstrated near immunity to TMV, ToMV, CMV, AlMV, PVX, PVY, and PLRV. He has evaluated the practical value of the virus-resistant transgenic plants in field tests, a necessary step prior to registration and commercialization.

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Dr. Frederic L. Kolb
Agronomy Department
University of Illinois
AW-101 Turner Hall
1102 South Goodwin
Urbana, IL 61801

Dr. Fred Kolb is an Associate Professor of Plant Breeding at the University of Illinois. His research is on breeding and genetics of soft red winter wheat and spring oat, including variety and germplasm development. One area of emphasis in his program has been breeding for tolerance to barley yellow dwarf virus in wheat and oat. Research in progress or recently completed includes: assessment of yield loss due to BYDV in oat and wheat, effects of BYDV on growth rate of wheat and oat throughout the growing season, effects of BYDV on root growth in wheat grown in an aeroponic system, development of near-isogeneic lines of oat differing in BYDV tolerance, association of molecular markers with genes for BYDV tolerance in oat, evaluation of sources of BYDV tolerance and introgression of genes for tolerance

from different sources into the same genotype, and evaluation of imidacloprid as a seed treatment to control BYDV.

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Mr. Cliff Lawson
Crop Protection Division
Monsanto Company
700 Chesterfield Village Parkway
St. Louis, MO 63198

Mr. Lawson is a Research Plant Pathologist with Monsanto. His research responsibilities are molecular plant virology and the application of biotechnology to the cloning and expression of plant viral genes in plants for the genetic improvement of plants for virus resistance. He is currently interested in several aspects of BYDV such as (1) epidemiology of BYDV in winter wheat, (2) molecular diversity and distribution of BYDV subgroups and strains in the U.S. and world wide, and (3) determinants important to the vector/virus interaction. The ARS BYDV workshop is an opportunity for Mr. Lawson to receive direction and assistance in understanding the complexities of this disease.

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Dr. W. Allen Miller
Associate Professor
Plant Pathology Dept.
Iowa State University
351 Bessey Hall
Ames, Iowa 50011

Dr. Miller is an Associate Professor at Iowa State University. His area of responsibility is in molecular virology research, and teaching molecular plant pathology. All of his research is on BYDV with funding to study BYDV gene expression; BYDV replication/ recombination; satellite BYDV RNA replication, effects on symptoms; genetic engineering for BYDV resistance (transgenic oats); risk assessment of genetically engineered BYDV resistance--risk of out-crossing to weedy oat relatives and risk of complementation and recombination between transgene and invading virus.

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Dr. Charles F. Murphy
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In his position with USDA, Agricultural Research Service, Dr. Murphy is responsible for leadership of ARS grain crop production research. He serves as the focal point for national strategic planning and policy analysis for his research programs in the agency. In this capacity he leads, guides, and facilitates planning activities for problem solving programs

and projects. He is involved in multi-disciplinary planning within ARS and between ARS and other Federal and State agencies as well as academic institutions, private industry, and international organizations.

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Dr. Herb Ohm
Professor
Agronomy Department
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West Lafayette, IN 47907-1150
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Dr. Ohm is a Professor at Purdue University. With wheat, Dr. Ohm is working on transfer of BYDV resistance from thinopyrum intermedium to wheat which includes genetics of resistance; DNA markers; and isolation and cloning of genes for resistance (with Joe Anderson). With oats, his research includes breeding for increased degrees of resistance/tolerance--transgressive segregation, and identifying DNA markers for specific genes for resistance/tolerance.

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Dr. Keith Perry
Assistant Professor
Department of Botany & Plant Pathology
Purdue University
West Lafayette, IN 47907

Dr. Perry is a virologist in the Department of Botany and Plant Pathology at Purdue University. His research with BYDV is directed toward developing resistance in wheat and oats. He is taking two approaches in this work. One strategy is to transform plants for resistance using viral coat and read-through protein genes. The other approach is as part of the small grains breeding group at Purdue. His contribution is to identify individual plants and breeding lines which support very low or undetectable levels of virus replication and accumulation. He is also maintaining five BYDV isolates representative of the diversity of BYDV strains and four common grain aphids. These are used to evaluate the breadth of genetic resistance.

A second component of his program is on nonpersistent transmission of plant viruses by aphids; He is maintaining additional colonies of aphids for this work.

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Dr. Hari Sharma
Agronomy Department
Purdue University
West Lafayette, IN 47907

Dr. Sharma is a Research Agronomist with Purdue University. His responsibilities and interests include identifying new useful genes in wheat relatives; improving genetic base of wheat by transfer of useful genes, particularly genes for BYDV; and characterizing the introgression by cytogenetic and molecular techniques.

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Dr. Fran Webster
The Quaker Oats Company
John Stuart Research Laboratories
617 West Main Street

Barrington, IL 60010

Dr. Webster is a Principal Scientist with The Quaker Oats Company. The principle accountability of his position is coordination of Quaker's Oat Biotechnology Program. Secondary research objectives include characterization of cereal quality and developing new methods of assessing cereal quality and functionality.

The Biotech program's principle objective is development of molecular technologies for use in oat improvement. Specific interests include development and application of marker assisted selection (MAS) and transformation technologies. With regard to BYDV, research is in progress to identify quantitative locus associated with BYDV tolerance/resistance. Once sources of tolerance/resistance are identified, MAS will be evaluated as a means of rapid and precise transfer of the BYDV loci to elite germplasm. Additionally, this research will provide the ability to genetically characterize the various sources of resistance and hopefully, to identify new breeding strategies for enhancing BYDV tolerance/resistance.

Oat transformation technologies provide the opportunity to investigate alternative methods of providing durable resistance to BYDV. Specific approaches of interest include coat protein or replicase mediated resistance. Various sense or antisense strategies or ribozymes all offer potentially viable opportunities for generating new and more effective forms of resistance to BYDV.

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Dr. Young is a Professor in the Department of Plant Pathology at Montana State University. Professor Young 's laboratory is interested in BYDV gene expression and function. The major research questions being addressed include:

- The identification of the viral gene product(s) responsible for controlling BYDV transmission specificity.
- Identification and characterization of BYDV virion structural components using a combination of molecular and structural approaches.
- Analysis of replicase based resistance to luteoviruses in transgenic plants.

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# WORKSHOP OBJECTIVES

Barley yellow dwarf virus (BYDV) posses the most serious disease threat to small grain production in the United States and, arguably, worldwide. ARS programs have constituted a major portion of the U.S. effort on this disease problem since it was first recognized as a serious problem nearly forty years ago. ARS has also assumed responsibility for periodically assembling barley yellow dwarf virus workers to facilitate planning, coordination, and effectiveness.

This workshop was convened to assess current research efforts and research opportunities and, specifically, to help ARS focus its available resources on those problems of greatest relevance. The invited participants brought a broad range of scientific expertise and perspectives to the workshop. Their willingness to share expertise, experience, and vision was essential to the fulfillment of the workshop objectives.

The order of business was:

- Introductions and overview of current BYDV research efforts
- Prioritization of BYDV research needs (group consensus based upon modified nominal group technique)
- Summary discussion

# RESEARCH NEEDS IDENTIFICATION

A no discussion, no debate "brainstorming" technique was utilized to elicit a listing of research needs from the group. The initial listing was then organized by the program leaders, presented to the full group, and slightly modified into a listing as follows:

## HOST

1. Screening Methodology
    a. Selection of virus isolates to be used for resistance screening
    b. Non-aphid inoculation
    c. Improved disease rating
    d. Optimization of field testing
    e. Early prediction of resistance

2. Natural Resistance
    a. Resistance gene mapping and cloning
    b. Identification of resistance genes
    c. Resistance genes from other species
    d. Number of genes for tolerance/resistance
    e. Improved techniques for wide hybridization
    f. Identification of desirable types of resistance
    g. Synergism of resistance types
    h. Molecular markers for resistance genes
    i. Incorporation of resistance/tolerance genes into adapted backgrounds
    j. Development and evaluation of marker-assisted breeding
    k. Germplasm evaluation

3. Transgenic Resistance
    a. Identification of most effective strain (gene) to use
    b. Improved transformation technology
    c. Development of phloem-specific promoters
    d. Characterization of transgenic expression
    e. Efficacy of transgene vs. natural resistance
    f. Evaluation of cp(transgene) - mediated resistance
    g. Rapid varietal identification method
    h. Risk assessment of transgenics

4. Virus-Host Interactions
    a. Virus titer vs symptomatology
    b. Synergism between virus and pathogens/stresses

c. Host components involved in virus replication and movement
d. Influence of infection on carbohydrate flow.

5. Vector Resistance
   a. Mechanism of non-preference
   b. Durability of resistance
   c. Efficacy of resistance in controlling epidemics

6. Crop Loss Assessment
   a. Development of methods to quantify losses
   b. Disease forecast models
   c. Effect of BYDV on grain quality

7. Mechanisms of Resistance
   a. Disease determinants in host
   b. Non-host resistance
   c. Mature plant resistance
   d. Host tolerance determinants
   e. Model systems for resistance
   f. Durability of resistance
   g. Genotype x environment interactions

8. Disease Control
   a. IPM methods
   b. Crop management
   c. Epidemiological effects of tolerant/resistant plants
   d. Strategies for resistance gene deployment

## VIRUS

9. Ecology
   a. Strain distribution and incidence
   b. Effect of environment on replication
   c. Influences on viral fitness
   d. Host range of prevalent strains
   e. Environmental effects on strain distribution
   f. Non-agricultural strains - distribution and identification

10. Characterization
   a. Taxonomy and nomenclature
   b. Virion structural dynamics
   c. Mutation rate

d. Storage stability
e. Improved cloning and sequencing
f. Identification of unrecognized serotypes
g. Presence of satellites and DI RNAs

11. Biology / Gene Function
    a. Virus movement
    b. Gene regulation
    c. Viral gene expression, replication
    d. Basis for phloem limitation
    e. Assembly - basis for control
    f. Mechanism of pathogenicity
    g. Host range determinants
    h. Control of symptom expression
12. Assay
    a. Improvement of diagnostic methods (PCR & serology)
    b. Increase concentration of virus in tissue
    c. Improve extraction technology
    d. Strain separation techniques

13. Virus-Virus Interactions
    a. Synergism among strains
    b. Cross protection
    c. Heterologous transcapsidation
    d. Recombination of transgenes and strains
    e. Viral gene interactions

## VECTOR

14. Virus - Vector Interactions
    a. Mechanism of transmission
    b. Signif. of readthrough protein between BYDV & aphid-virus/symbionts
    c. Variation in virus strain - aphid species/biotype specificity
    d. Effect of vector on virus evolution
    e. RMV increase as related to vector specificity changes

15. Ecology
    a. Temporal population dynamics
    b. Effect of cropping patterns on populations
    c Occurrence of aphid types by geographic region

16. Epidemiology
    a. Correlation between aphid biotypes and epidemics
    b. Factors impacting epidemiology - aphid source, color cues
    c. Effect of changes in fraction of viruliferous aphids
    d. Role of root aphids
    e. Insect overwintering mechanism and source of viral inoculum
    f. Forecasting based on aphid populations

17. Characteristics
    a. Biotype diagnostics

18. Biology
    a. Genetic system
    b. Alternate hosts
    c. Source of aphids

19. Control
    a. Effectiveness of insecticides and economics of use
    b. Biological control
    c. Insecticide genes in plants
    d. Management practices affecting aphid populations
    e. Development of resistance to insecticides

# RESEARCH NEEDS ASSESSMENT

A modified nominal group technique allowed each participant to vote for, in rank order, their top four individual research needs. A first choice was worth 4 points, a second choice 3 points, etc. The number of votes received and the total score for each item are indicated in bold in the listing shown below. The participants also voted, in rank order, for their top two research needs categories, within each of the broad (host, virus, and vector) categories and for their top four categories, overall. The table, shown on page 18, indicates the results of this voting procedure, along with an inventory of current research activities, in each of these areas, at the locations of participants and, in the case of University Park, a close collaborator.

## HOST

1. Screening Methodology
   - **3-7** a. Selection of virus isolates to be used for resistance screening
   - **2-3** b. Non-aphid inoculation
   - **3-9** c. Improved disease rating
   - **2-4** d. Optimization of field testing
   - **1-1** e. Early prediction of resistance

2. Natural Resistance
   - **7-20** a. Resistance gene mapping and cloning
   - **4-17** b. Identification of resistance genes
   - **3-8** c. Resistance genes from other species
   - d. Number of genes for tolerance/resistance
   - **1-3** e. Improved technique for wide hybridization
   - **4-11** f. Identification of desirable types of resistance
   - g. Synergism of resistance types
   - **1-4** h. Molecular markers for resistance genes
   - **5-22** i. Incorporation of resistance/tolerance genes into adapted backgrounds
   - **2-8** j. Development and evaluation of marker-assisted breeding
   - **4-16** k. Germplasm evaluation

3. Transgenic Resistance
   - **6-22** a. Identification of most effective strain (gene) to use
   - **4-13** b. Improved transformation technology
   - c. Development of phloem-specific promoters
   - **3-8** d. Characterization of transgenic expression
   - **4-10** e. Efficacy of transgenic vs natural resistance
   - **5-16** f. Evaluation of cp(transgene) - mediated resistance
   - g. Rapid varietal identification method
   - **1-1** h. Risk assessment of transgenics

4. Virus-Host Interactions
   - **1-1** a. Virus titer vs symptomatology
   - **1-3** b. Synergism between virus and pathogens/stresses
   - **5-19** c. Host components involved in virus replication and movement
   - d. Influence of infection on carbohydrate flow.

5. Vector Resistance
   - **1-2** a. Mechanism of non-preference
   - b. Durability of resistance
   - **2-2** c. Efficacy of resistance in controlling epidemics

6. Crop Loss Assessment
   - **7-25** a. Development of methods to quantify losses
   - **1-1** b. Disease forecast models
   - c. Effect of BYDV on grain quality

7. Mechanisms of Resistance
   - **2-8** a. Disease determinants in host
   - b. Non-host resistance
   - c. Mature plant resistance
   - **1-1** d. Host tolerance determinants
   - e. Model systems for resistance
   - **3-7** f. Durability of resistance
   - g. Genotype x environment interactions

8. Disease Control
   - **2-5** a. IPM methods
   - b. Crop management
   - c. Epidemiological effects of tolerant/resistant plants
   - **3-7** d. Strategies for resistance gene deployment

## VIRUS

9. Ecology
   - **18-66** a. Strain distribution and incidence
   - **2-6** b. Effect of environment on replication
   - c. Influences on viral fitness
   - **4-8** d. Host range of prevalent strains
   - **1-4** e. Environmental effects on strain distribution
   - f. Non-agricultural strains - distribution and identification

10. Characterization

| | |
|---|---|
| **2-3** | a. Taxonomy and nomenclature |
| | b. Virion structural dynamics |
| | c. Mutation rate |
| | d. Storage stability |
| **3-4** | e. Improved cloning and sequencing |
| **7-16** | f. Identification of unrecognized serotypes |
| | g. Presence of satellites and DI RNAs |

11. Biology / Gene Function

| | |
|---|---|
| **5-15** | a. Virus movement |
| **2-3** | b. Gene regulation |
| **13-47** | c. Viral gene expression, replication |
| **2-5** | d. Basis for phloem limitation |
| | e. Assembly - basis for control |
| **11-38** | f. Mechanism of pathogenicity |
| **1-3** | g. Host range determinants |
| **2-6** | h. Control of symptom expression |

12. Assay

| | |
|---|---|
| **11-38** | a. Improvement of diagnostic methods (PCR & serology) |
| **1-1** | b. Increase concentration of virus in tissue |
| | c. Improve extraction technology |
| **1-1** | d. Strain separation techniques |

13. Virus-Virus Interactions

| | |
|---|---|
| **5-15** | a. Synergism among strains |
| **1-1** | b. Cross protection |
| | c. Heterologous transcapsidation |
| **2-2** | d. Recombination of transgenes and strains |
| **1-3** | e. Viral gene interactions |

## VECTOR

14. Virus - Vector Interactions

| | |
|---|---|
| **15-57** | a. Mechanism of transmission |
| **1-1** | b. Signif. of readthrough protein between BYDV & aphid-virus/symbionts |
| **15-49** | c. Variation in virus strain - aphid species/biotype specificity |
| | d. Effect of vector on virus evolution |
| | e. RMV increase as related to vector specificity changes |

15. Ecology

| | |
|---|---|
| **7-16** | a. Temporal population dynamics |
| **5-12** | b. Effect of cropping patterns on populations |
| **5-10** | c. Occurrence of aphid types by geographic region |

16. Epidemiology

| | |
|---|---|
| **10-29** | a. Correlation between aphid biotypes and epidemics |
| **4-9** | b. Factors impacting epidemiology - aphid source, color cues |
| | c. Effect of changes in fraction of viruliferous aphids |
| | d. Role of root aphids |
| **3-8** | e. Insect overwintering mechanism and source of viral inoculum |
| **2-5** | f. Forecasting based on aphid populations |

17. Characteristics

| | |
|---|---|
| **1-2** | a. Biotype diagnostics |

18. Biology

| | |
|---|---|
| **1-3** | a. Genetic system |
| **5-14** | b. Alternate hosts |
| **1-3** | c. Source of aphids |

19. Control

| | |
|---|---|
| **3-10** | a. Effectiveness of insecticides and economics of use |
| **3-12** | b. Biological control |
| **7-22** | c. Insecticide genes in plants |
| **6-22** | d. Management practices affecting aphid populations |
| **1-1** | e. Development of resistance to insecticides |

## BARLEY YELLOW DWARF VIRUS PRIORITIES

| PRIORITY/LOCATION | RESEARCH NEEDS | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | HOST | | | | | | | | VIRUS | | | | | VECTOR | | | | | |
| | Screening Methodology 1 | Natural Resistance 2 | Transgenic Resistance 3 | Virus - Host Interaction 4 | Vector Resistance 5 | Crop Loss Assessment 6 | Mechanism of Resistance 7 | Disease Control 8 | Ecology 9 | Characterization 10 | Biology/Gene Functions 11 | Assay 12 | Virus - Virus Interaction 13 | Virus - Vector Interactions 14 | Ecology 15 | Control 16 | Characteristics 17 | Epidemiology 18 | Biology 19 |
| **Priorities** | | | | | | | | | | | | | | | | | | | |
| Separate | 2 | 21 | 14 | 4 | 1 | 9 | 5 | 1 | 20 | 1 | 30 | 6 | - | 24 | 5 | 12 | - | 16 | - |
| Overall | 3 | 39 | 24 | 8 | 3 | 13 | 6 | 2 | 9 | 2 | 26 | 2 | - | 12 | - | 7 | - | 10 | - |
| **Locations** | | | | | | | | | | | | | | | | | | | |
| ARS-Fargo | | x | | | | x | | | | | | | | | | | | | |
| ARS-Ithaca | | | | x | | | x | x | x | x | x | | x | x | x | x | | x | |
| ARS-Lincoln | | | x | | | | | | x | x | | x | | | | | | | |
| ARS-Urbana | x | x | x | | | | x | | | x | x | x | x | | | | | x | x |
| ARS-W. Lafayette | | x | x | x | | | x | | | | | | | | | | | | |
| Ames | | | x | x | | | | | | x | x | | x | x | | | | | |
| Bozeman | | | x | | | | x | | | x | x | x | | x | | | | | |
| CIMMYT | x | x | | x | | | | | x | | | | | | x | | | | |
| Ithaca | x | x | | | | | x | x | x | x | | | x | x | x | x | | x | x |
| Monsanto | x | | x | x | | | | x | x | x | x | x | x | x | | x | | | |
| Univ. Park | | x | | | | | | | | | | | | x | | | | x | |
| W.Lafayette | x | x | x | x | | x | x | x | x | x | | | x | | | | | | |
| Urbana | x | x | | | | x | x | | x | x | x | x | | x | | x | | | |

## SUMMARY

A major objective of this workshop was to determine the degree to which current research activities are addressing identified research needs/priorities. To a large degree, current research (both ARS and non-ARS) seems well directed to identified priority needs. The greatest disparity to emerge related to a strong expression of interest in crop loss assessments. There was little interest expressed by the participants in personally conducting crop loss research but there was a strong sense that more such data were needed. Although the workshop participants were in agreement as to the severity of the BYDV problem, domestically and worldwide, levels of industry and grant support for BYDV research may be dependent upon additional disease loss information.

Additional concern relates to the loss of the position formerly held by Dr. Hewings, at Urbana, Illinois. Activities associated with that position are considered critical to breeding programs incorporating natural resistance. Maintaining these activities, possibly under the direction of a support scientist, emerged as a priority consideration.

Specific priority research needs identified by the workshop participants will be a major consideration in formulating future ARS research relating to the BYDV problem.